DEC STD 116-9 Workmanship Standards Manual - Surface Mount

DOCUMENT IDENTIFIER: A-DS-EL00116-09-0000 Rev E, 20-Sep-1992

ABSTRACT: This standard provides the workmanship criteria to be applied in the manufacture and maintenance of Digital products that contain surface mount components.

APPLICABILITY: This standard is used as a training aid for new employees and is required for all personnel who manufacture and maintain Digital products that contain surface mount components.

STATUS: APPROVED 20-Sep-1992; use VTX SMC for current status.

This document is confidential and proprietary, and is the property of Digital Equipment Corporation. It is an unpublished work protected under applicable copyright laws.

© Digital Equipment Corporation 1990, 1992. All rights reserved.

DEC STD 116-9 Workmanship Standards Manual - Surface Mount

DOCUMENT IDENTIFIER: A-DS-EL00116-09-0000 Rev E, 20-Sep-1992

REVISION HISTORY:	Rev A,	20-May-1984	
	Rev B,	03-Nov-1986	ECO Number LJO01
	Rev C,	25-May-1990	ECO Number CTS02
	Rev D,	01-Jul-1991	ECO Number CTS03
	Rev E,	20-Sep-1992	ECO Number NRO04

Document Management Category:	Workmanship (MQW)
Responsible Department:	Technical Services for Manufacturing and Engineering (TME)
Responsible Person:	Steve Spaulding
SMC Writer:	Chip McConney

APPROVAL: This document has been reviewed and recommended for approval by the General Review group for DEC STD 116 and the Workmanship Committee.

Steve Spaulding, Chairperson - Workmanship Committee

Eric Williams - Standards Process Manager

Direct requests for further information to:

Steve Spaulding
Use $ VTX ELF for the latest location information.

Use VTX SMC to order copies of this document from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

The DIGITAL logo is a trademark of Digital Equipment Corporation.

CONTENTS

1 INTRODUCTION 1

2 LEVELS OF ACCEPTABLE AND UNACCEPTABLE WORKMANSHIP 1
2.1 LEVELS OF ACCEPTABILITY 1
2.2 LEVELS OF UNACCEPTABLE DEFECTS 2
2.3 Magnification and Lighting 2

3 DEFINITIONS 3

4 ELECTROSTATIC DISCHARGE DAMAGE 5

5 SOLDER CONNECTIONS 6

6 SOLDERING CONDITIONS — LEADLESS AND MULTI-LEADED COMPONENTS (WITH CASTELLATIONS) 7
6.1 OPTIMAL (REFERENCE) 7
6.2 MINIMUM ACCEPTABLE 8
6.2.1 Minimum Acceptable: Maximum Solder Conditions 8
6.2.2 Minimum Acceptable: Minimal Solder Conditions 8
6.3 UNACCEPTABLE 9
6.3.1 Unacceptable: Excessive Solder Conditions 9
6.3.2 Unacceptable: Insufficient Solder Conditions 9
6.3.3 Unacceptable: Absence of Wetting (Dewetting) 9

7 SOLDERING CONDITIONS — CHIP COMPONENTS AND TRANSISTORS 11
7.1 OPTIMAL (REFERENCE) 11
7.2 MINIMUM ACCEPTABLE 12
7.2.1 Minimum Acceptable: Maximum Solder Conditions 12
7.2.2 Minimum Acceptable: Minimal Solder Conditions 13
7.3 UNACCEPTABLE 14
7.3.1 Unacceptable: Excessive Solder Conditions 14
7.3.2 Unacceptable: Absence of Wetting — Nonwetting Conditions 15
7.3.3 Unacceptable: Leaching 15

8 ADHESIVES 16
8.1 OPTIMAL (REFERENCE) 16
8.2 MINIMUM ACCEPTABLE: ADHESIVE CONDITIONS 17
8.3 UNACCEPTABLE: ADHESIVE CONDITIONS 18

9 OPTIMAL (REFERENCE) SOLDERING CONDITIONS — WAVE SOLDER CHIP COMPONENTS (SIDE 2) 19

10 SOLDERING CONDITIONS — LOW PROFILE SMT DEVICES 20
10.1 MINIMUM ACCEPTABLE 20
10.2 UNACCEPTABLE 20

11 SOLDERING CONDITIONS — J-BEND LEADED COMPONENTS 22
11.1 OPTIMAL (REFERENCE) 22

11.2 MINIMUM ACCEPTABLE 23
11.2.1 Minimum Acceptable: Maximum Solder Conditions 23
11.2.2 Minimum Acceptable: Minimal Solder Conditions 24
11.3 UNACCEPTABLE 25
11.3.1 Unacceptable: Insufficient Solder Conditions 25
11.3.2 Unacceptable: Absence of Wetting (Nonwetting) 25

12 SOLDERING CONDITIONS — GULL-WING LEAD COMPONENTS (50-MIL AND 25-MIL PITCH) 26
12.1 OPTIMAL (REFERENCE) 26
12.2 MINIMUM ACCEPTABLE 27
12.2.1 Minimum Acceptable: Maximum Solder Conditions 27
12.2.2 Minimum Acceptable: Minimal Solder Conditions 28
12.3 UNACCEPTABLE 29
12.3.1 Unacceptable: Excessive Solder Conditions 29
12.3.2 Unacceptable: Insufficient Solder Conditions 30
12.3.3 Unacceptable: Absence of Wetting (Nonwetting) 30

13 SOLDERING CONDITIONS — BUTT JOINTS 31
13.1 GENERAL 31
13.2 OPTIMAL (REFERENCE) AND MINIMUM ACCEPTABLE 31

14 PAD ALIGNMENT — J-BEND LEADED COMPONENTS 32
14.1 OPTIMAL (REFERENCE) 32
14.2 MINIMUM ACCEPTABLE 32
14.3 UNACCEPTABLE 32

15 PAD ALIGNMENT — LEADLESS CHIP CARRIERS 33
15.1 OPTIMAL (REFERENCE) 33
15.2 MINIMUM ACCEPTABLE: PAD ALIGNMENT — LEADLESS CHIP CARRIERS 33
15.3 UNACCEPTABLE: PAD ALIGNMENT — LEADLESS CHIP CARRIERS 33

16 CHIP COMPONENT ALIGNMENT 34
16.1 OPTIMAL (REFERENCE) 34
16.2 ACCEPTABLE MINIMUM: CHIP COMPONENT ALIGNMENT 34
16.3 UNACCEPTABLE 35

17 PAD ALIGNMENT — GULL-WING COMPONENTS (25 AND 50 MIL-RIGID, FLEX-LEAD TAPE-BONDED COMPONENTS) 36
17.1 Optimal (Reference) 36
17.2 Minimum Acceptable: Pad Alignment — Gull-Wing Components 36
17.3 Unacceptable: Pad Alignment — Gull-Wing Components 36
17.4 Rotational Misalignment of Lead-On-Pad 37
17.5 FLEX-LEAD (12 ½-MIL PITCH) TECHNOLOGY NOTES 38
17.5.1 Technology Qualifier 38

18 DAMAGED COMPONENTS - SURFACE MOUNT ASSEMBLIES 38

Appendix A REFERENCED DOCUMENTS 39

A.1 EL-Class Digital Documents 39

A.2 Other Documents 39

Appendix B RELATED DOCUMENTS 41

B.1 EL-Class Digital Documents 41

FIGURES

1 Ceramic Leaded Chip Carrier (CLCC) 3
2 Ceramic Leaded Chip Carrier — Lead Area 3
3 Leadless Chip Carrier (LCC) Showing Castellations 4
4 Plastic Leaded Chip Carrier (PLCC) 4
5 Solder Contact Angle 6
6 Optimal (Reference): Leadless and Multi-leaded Components (With Castellations) 7
7 Minimum Acceptable: Maximum Solder Conditions 8
8 Minimum Acceptable: Minimal Solder Connections 8
9 Unacceptable: Excessive Solder Conditions 9
10 Unacceptable: Insufficient Solder Conditions 9
11 Soldering Conditions — Leadless Components (With Castellations) 10
12 Leadless Chip Carrier with Castellated Terminations — Joint Geometrical Description 10
13 Optimal (Reference): Soldering Conditions — Chip Components and Transistors 11
14 Minimum Acceptable: Maximum Solder Conditions 12
15 Minimum Acceptable: Minimal Solder Conditions 13
16 Unacceptable: Excessive Solder Conditions 14
17 Unacceptable: Absence of Wetting — Nonwetting Conditions 15
18 Unacceptable: Leaching 15
19 Optimal (Reference): Adhesive Conditions 16
20 Minimum Acceptable: Adhesive Conditions 17
21 Minimum Acceptable: Adhesive Conditions 17
22 Unacceptable: Adhesive Conditions 18
23 Unacceptable: Adhesive Conditions 18
24 Optimal (Reference) Soldering Conditions — Wave Solder Chip Components (Side 2) 19
25 Soldering Conditions — Low Profile SMT Devices 20
26 Optimal (Reference): Soldering Conditions — J-Bend Leaded Components 22
27 Minimum Acceptable: Maximum Solder Conditions 23
28 Minimum Acceptable: Minimal Solder Conditions 24
29 Unacceptable: Insufficient Solder Conditions 25
30 Unacceptable: Absence of Wetting (Nonwetting) 25
31 Optimal (Reference): Soldering Conditions — Gull-Wing Lead Components 26
32 Minimum Acceptable: Maximum Solder Conditions 27
33 Minimum Acceptable — Minimal Solder Conditions 28
34 Unacceptable: Excessive Solder Condition 29
35 Unacceptable: Insufficient Solder Conditions 30
36 Unacceptable: Absence of Wetting (Nonwetting) 30

37 Optimal (Reference) and Minimum Acceptable: Butt Joint Soldering Conditions 31
38 Minimum Acceptable: Pad Alignment — J-Bend Leaded Components 32
39 Minimum Acceptable: Pad Alignment — Leadless Chip Carriers 33
40 Optimal (Reference): Chip Component Alignment 34
41 Acceptable Minimum: Chip Component Alignment 34
42 Unacceptable: Component Alignment 35
43 Pad Alignment — Gull-Wing Components 36
44 Pad Alignment — Lead-to-Pad Clearance 37

TABLES

1 Maximum Allowable Lead-to-Pad Misalignment 37

1 INTRODUCTION

This standard provides the workmanship criteria to be applied to Digital products that contain surface mount components. The equipment and processes associated with surface mount technology (SMT) are continually undergoing improvements and modifications as the technology matures. Therefore, this standard will be reviewed and updated to reflect those processes best suited to the manufacturing goals of the Corporation. This standard should be used as a training guide and as a reference for all personnel who manufacture and maintain Digital products containing surface mount components.

2 LEVELS OF ACCEPTABLE AND UNACCEPTABLE WORKMANSHIP

The following levels of acceptability are used to describe workmanship conditions throughout this standard.

2.1 LEVELS OF ACCEPTABILITY

Optimal (Reference)

The nominal condition from which minimal acceptable and unacceptable variations are described.

Minimum Acceptable

The least degree of quality that will be accepted per Digital standards and engineering specifications.

Incidental Defect

A defect in a product that judgment and experience indicate will meet reliable standards of operation (form, fit, or function), but may depart from established standards and have little bearing on the effective use or operation of the unit, assembly, or system. If this condition is repetitive, it may indicate a process degradation.

Unacceptable

The level below the incidental defect condition whereby a product that contains a critical or major defect must be either reworked to bring it to the acceptable condition, or scrapped if it is not repairable. An exception to this is defined under subhead 2.2, Minor Defect.

NOTE

The above requirements shall prevail when specific information does not appear on engineering documentation. Engineering documentation may define specific quality requirements that take precedence over general workmanship standards.

2.2 LEVELS OF UNACCEPTABLE DEFECTS

The following levels of unacceptability are used to describe workmanship conditions throughout this standard.

Critical Defect

A critical defect is one that judgment and experience indicates could result in a potential hazard or unsafe condition for individuals who are using, maintaining, or are near a unit, assembly or system.

Critical defects must be reworked immediately to a safe condition or have the potential hazard removed.

No product with a critical defect may move through the manufacturing process.

Major Defect

A major defect is one that results in failure or reduces, mechanically or electrically, the usability of the unit, assembly, or system for its intended purposes. The unit will or does fail for reasons of either form, fit, or function.

Minor Defect

A minor defect is one that judgment and experience indicates may or can cause a form, fit, or functional failure in the unit. Rework of this condition is not necessary if the customer will accept the unit with the defect.

2.3 Magnification and Lighting

Magnification tools and lighting used for inspection shall be commensurate with the size of the item being processed. The magnification used to inspect solder connections shall be based on the minimum width of the pad used for the device being inspected. The following magnification shall apply.

Pad Width	Inspection	Referee
>0.5 mm (>0.020 in)	1.75X-4X	10X
0.25 - 0.5 mm (0.010 - 0.020 in.)	10X	20X
<0.25 mm (0.010 in)	20X	30X

Referee conditions shall only be used to verify product rejected at the inspection magnification. For assemblies with mixed pad widths, the greater magnification may be used for the entire assembly.

The tolerance for magnification aids is 15 percent of the selected magnification power. For example, ± 15% or range of 30% centered at the selected magnification power.

3 DEFINITIONS

The following are definitions for terminology used throughout this document that relate to surface mount technology.

castellation — The vertical metallized portion of the leadless chip carrier pad. See Figure 3.

chip carriers:

ceramic leaded chip carrier (CLCC) — A ceramic leaded package for semiconductor die. See Figures 1 and 2.

Figure 1: Ceramic Leaded Chip Carrier (CLCC)

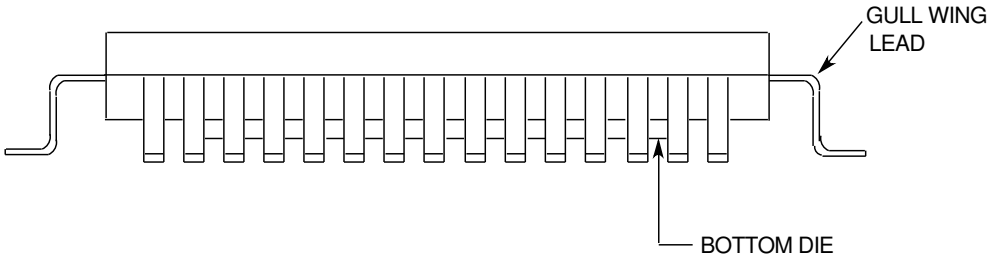
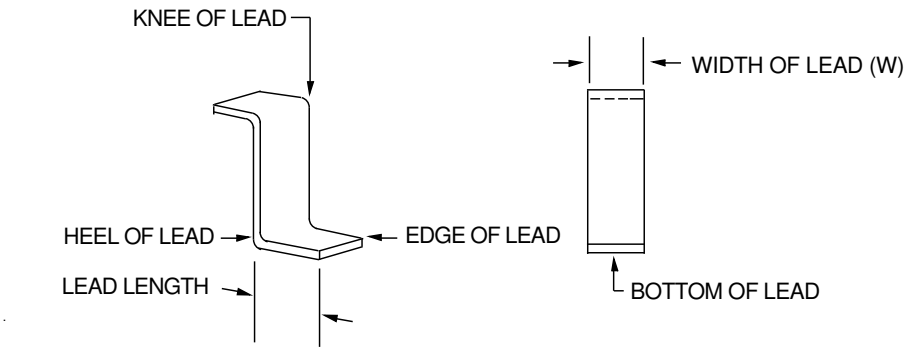
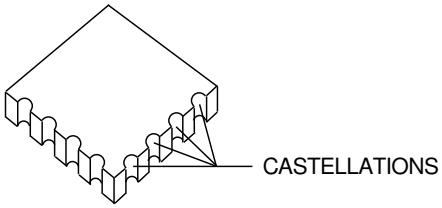


Figure 2: Ceramic Leaded Chip Carrier — Lead Area



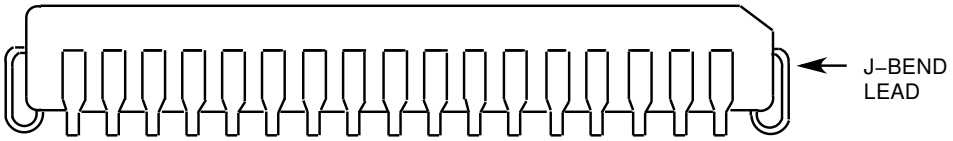
leadless chip carrier (LCC) — A ceramic leadless package for semiconductor die. See Figure 3. LCC devices on Digital products are not allowed on FR-4 or equivalent printed-wiring board substrates. Refer to *DEC STD 030-3 Module Manufacturing Standard — Component Selection Rules* for additional information.

Figure 3: Leadless Chip Carrier (LCC) Showing Castellations



plastic leaded chip carrier (PLCC) — A plastic leaded package for semiconductor die. See Figure 4.

Figure 4: Plastic Leaded Chip Carrier (PLCC)



dewetting — A condition characterized by solder not completely covering the surfaces to be bonded. Solder may appear as droplets or balls having withdrawn from previously wet adjacent areas.

drawbridging — See tombstoning.

footprint — The flat surface of the substrate pad required for mounting surface mountable components.

insufficient solder — The quantity of solder in the solder joint which results in the inability of the solder joint to withstand the mechanical and thermal stress applied during product life.

leaching — The dissolution of the end termination on ceramic chip capacitors and resistors, exposing the base ceramic of the component.

LED — Light Emitting Diode

nonwetting — A condition whereby a surface has contacted molten solder, but no solder adhered.

open solder connection — The lack of electrical connection due to absence of solder.

pad — The portion of a conductive pattern usually, but not exclusively, used for the connection or attachment, or both, of components.

SOIC — Small Outline Integrated Circuit: A package in which an integrated circuit die can be mounted to form a surface mounted component. It is made of a plastic material that can withstand high temperatures and has leads formed in a gull-wing shape along its two longer sides for connection to a printed-wiring board footprint.

solder bridge — The formation of a conductive path between conductors.

SOT — Small Outline Transistor

SSOP — Shrink Small Outline Package

tombstoning — Chip components (such as transistors and capacitors) that stand on their terminal ends.

TSOP — Thin Small Outline Package

4 ELECTROSTATIC DISCHARGE DAMAGE

Surface mount components are highly sensitive to electrostatic discharge (ESD). All precautions described in *DEC STD 067-0 Electrostatic Discharge - Sensitive Devices* shall be exercised during assembly, inspection, test, and maintenance of Digital's surface mount assemblies.

Equipment required to prevent damage to surface mount components from electrostatic discharge shall be used as described in DEC STD 067-0.

5 SOLDER CONNECTIONS

The acceptable solder connection must indicate evidence of wetting and adherence when the solder blends to the soldered surface, forming a contact angle of 90 degrees or less except when the quantity of solder results in a contour which extends over the edge of the pad. See Figure 5.

Solder fillets must have a generally smooth appearance and a satin luster is permissible. The following conditions are acceptable but indicate that the process is approaching its upper or lower control limits.

a. Voids and blow holes where wetting is evident, which do not reduce solder volume below allowable minimum.

b. Outline of lead is not visible in solder fillet because of excess solder.

c. Solder fillet may extend through the top bend. However, solder must not touch package body or end of seal unless they are low profile SMT (surface mount technology) devices such as SOICs, SOTs, TSOPs, SSOPs, or LEDs.

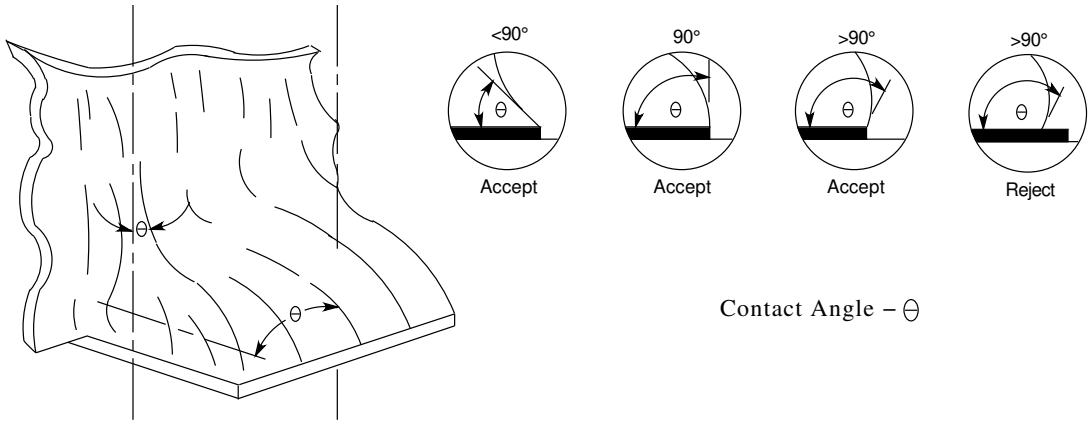
d. Solder should not extend under the body of low profile SMT devices.

e. The currently qualified hot bar attach process may result in trace evidence of bar contact pressure across the leads. This contact evidence is not to be considered during accept or reject decisions.

There are solder alloy compositions, lead or printed board plattings and special soldering processes (for example, slow cooling with large mass printed-wiring boards) that may produce dull, matte, gray, or grainy appearing solders that are normal for the material or process involved. These solder fillets are acceptable.

A smooth transition from pad to connection surface or component lead must be evident. A line of demarcation or transition zone where applied solder blends with solder coating, solder plate, or other surface material is acceptable provided that wetting is evident. In the case of fused solder coatings, presence of the applied solder above the rim of the hole is not required if the hole wall and component lead exhibit good wetting.

Figure 5: Solder Contact Angle



6 SOLDERING CONDITIONS — LEADLESS AND MULTI-LEADED COMPONENTS (WITH CASTELLATIONS)

The following criteria apply to leadless components soldered to a surface mount module.

6.1 OPTIMAL (REFERENCE)

The following describes optimal (reference) conditions. See Figures 6 and 11.

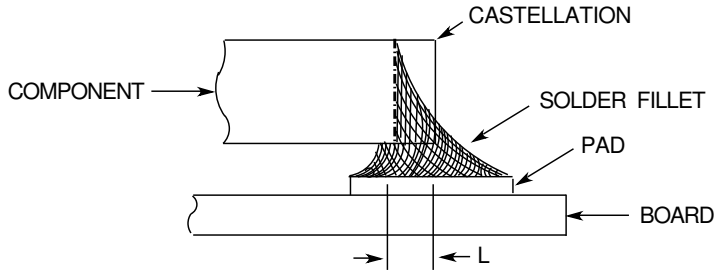
a. Good solder fillet has a concave appearance, is smooth, has no grainy appearance, and has a smooth transition from both component lead and pad terminations.

b. There is a full solder coverage of metallization on castellation.

c. Solder fillet has no cracks.

d. The solder fillet extends beneath the component termination (L) or the full length of the pad, whichever is smaller.

Figure 6: Optimal (Reference): Leadless and Multi-leaded Components (With Castellations)



6.2 MINIMUM ACCEPTABLE

The following describes minimum acceptable solder conditions for leadless and multi-leaded components with castellations.

6.2.1 Minimum Acceptable: Maximum Solder Conditions

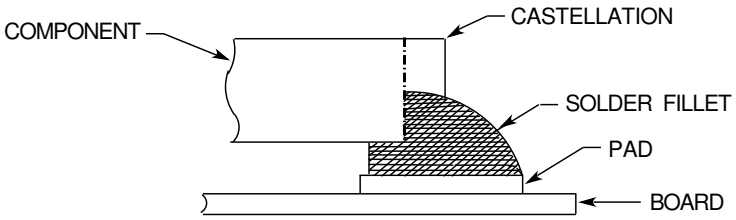
The following describes minimum acceptable conditions. See Figures 7, 11, and 12.

a. Solder fillet has a convex appearance.

b. Good wetting is visible at the edges of fillet on component and pad.

c. Solder fillet has no cracks.

Figure 7: Minimum Acceptable: Maximum Solder Conditions



6.2.2 Minimum Acceptable: Minimal Solder Conditions

The following describes minimum acceptable conditions. See Figures 8, 11, and 12.

a. There is a low solder fillet and a thin layer of solder with good wetting on pad.

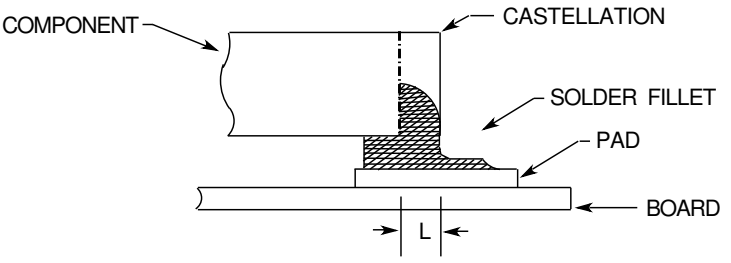
b. Solder wetting is visible at castellation and the pad.

c. Solder does not need to be extended to the edge of the pad, provided there is no evidence of dewetting.

d. Solder fillet has no cracks.

e. The length of the solder fillet beneath the component termination (L) must extend over the full length of the pad or component, whichever is smaller.

Figure 8: Minimum Acceptable: Minimal Solder Connections



6.3 UNACCEPTABLE

The following describes unacceptable solder conditions for leadless and multi-leaded components with castellations.

6.3.1 Unacceptable: Excessive Solder Conditions

The following describes unacceptable conditions. See Figures 9, 11, and 12.

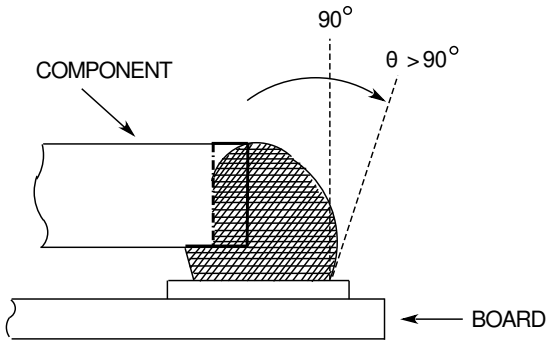
a. Excessive amount of solder is present and the outline of component termination is not visible.

b. It is not possible to see if wetting exists at the castellation.

c. Solder did not wet to the pad, or bulges at the component body, exceeding 90 degrees.

d. Cracks in solder fillet are unacceptable.

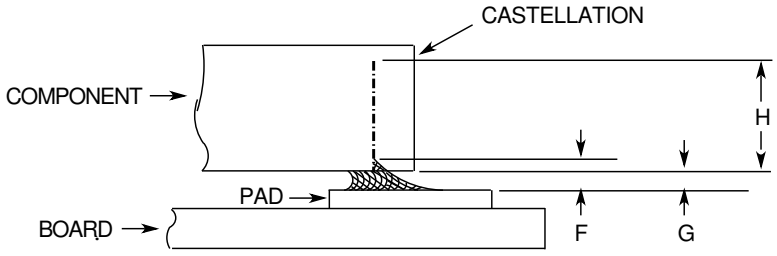
Figure 9: Unacceptable: Excessive Solder Conditions



6.3.2 Unacceptable: Insufficient Solder Conditions

If the solder height (F) is less than 25 percent of the castellation height (H), the condition is unacceptable. See Figures 10, 11, and 12.

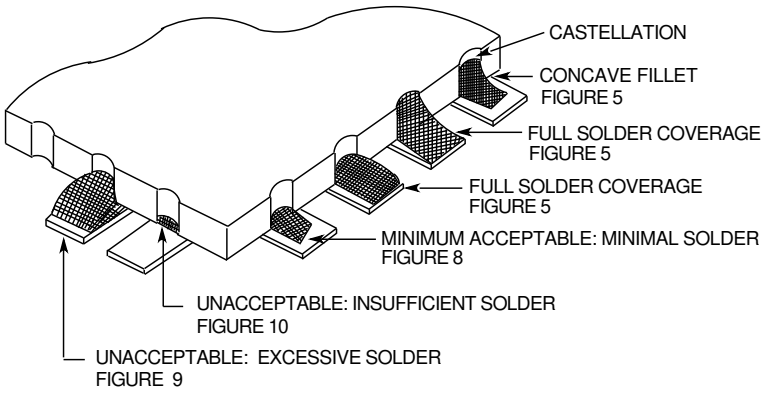
Figure 10: Unacceptable: Insufficient Solder Conditions



6.3.3 Unacceptable: Absence of Wetting (Dewetting)

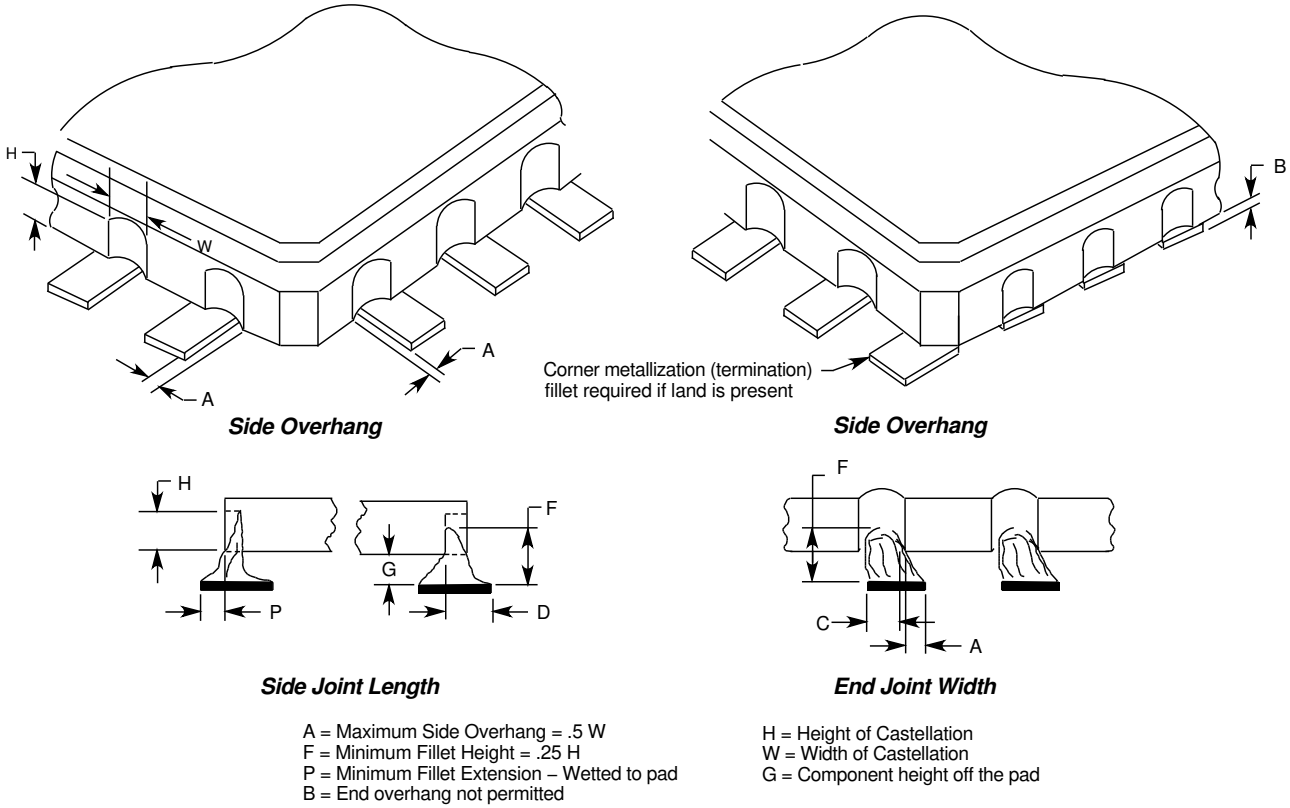
Absence of visible wetting on pad or termination band is unacceptable.

Figure 11: Soldering Conditions — Leadless Components (With Castellations)



.

Figure 12: Leadless Chip Carrier with Castellated Terminations — Joint Geometrical Description



A = Maximum Side Overhang = .5 W
F = Minimum Fillet Height = .25 H
P = Minimum Fillet Extension – Wetted to pad
B = End overhang not permitted

H = Height of Castellation
W = Width of Castellation
G = Component height off the pad

7 SOLDERING CONDITIONS — CHIP COMPONENTS AND TRANSISTORS

The following criteria applies to leadless components with termination bands soldered to surface mount boards.

7.1 OPTIMAL (REFERENCE)

The following describes optimal (reference) conditions. See Figure 13.

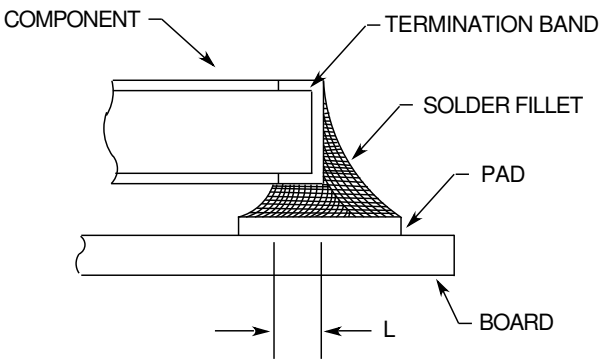
a. Good solder fillet has a concave appearance, is smooth, has no grainy appearance, and has a smooth transition from both component lead and pad terminations.

b. There is full solder coverage on component termination and pad.

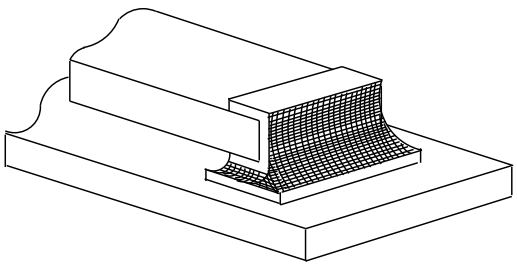
c. Solder fillet has no cracks.

d. The solder fillet extends beneath the component termination band (L) or the full length of the pad, whichever is smaller.

Figure 13: Optimal (Reference): Soldering Conditions — Chip Components and Transistors



SIDE VIEW



THREE–DIMENSIONAL VIEW

7.2 MINIMUM ACCEPTABLE

The following describes minimum acceptable solder conditions for chip components and transistors.

7.2.1 Minimum Acceptable: Maximum Solder Conditions

The following describes minimum acceptable conditions. See Figure 14.

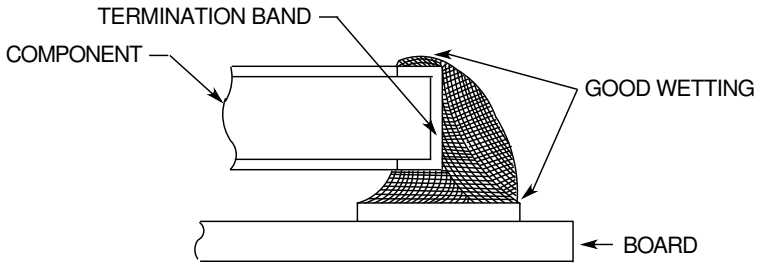
a. Solder fillet has a convex appearance and may overhang the edge of pad.

b. Good wetting is visible at the edges of pad and component.

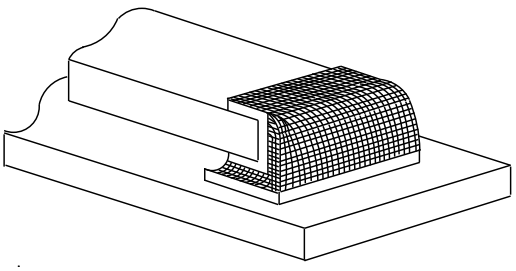
c. Solder fillet has no cracks.

d. Solder may flow onto the top termination of the component but shall not extend on to the component body.

Figure 14: Minimum Acceptable: Maximum Solder Conditions



SIDE VIEW



THREE–DIMENSIONAL VIEW

7.2.2 Minimum Acceptable: Minimal Solder Conditions

The following describes minimum acceptable conditions. See Figures 15-A, B, and C.

a. There is a low solder fillet and a thin layer of solder with good wetting on pad and component. See Figure 15-A.

b. Solder wetting is visible on pad.

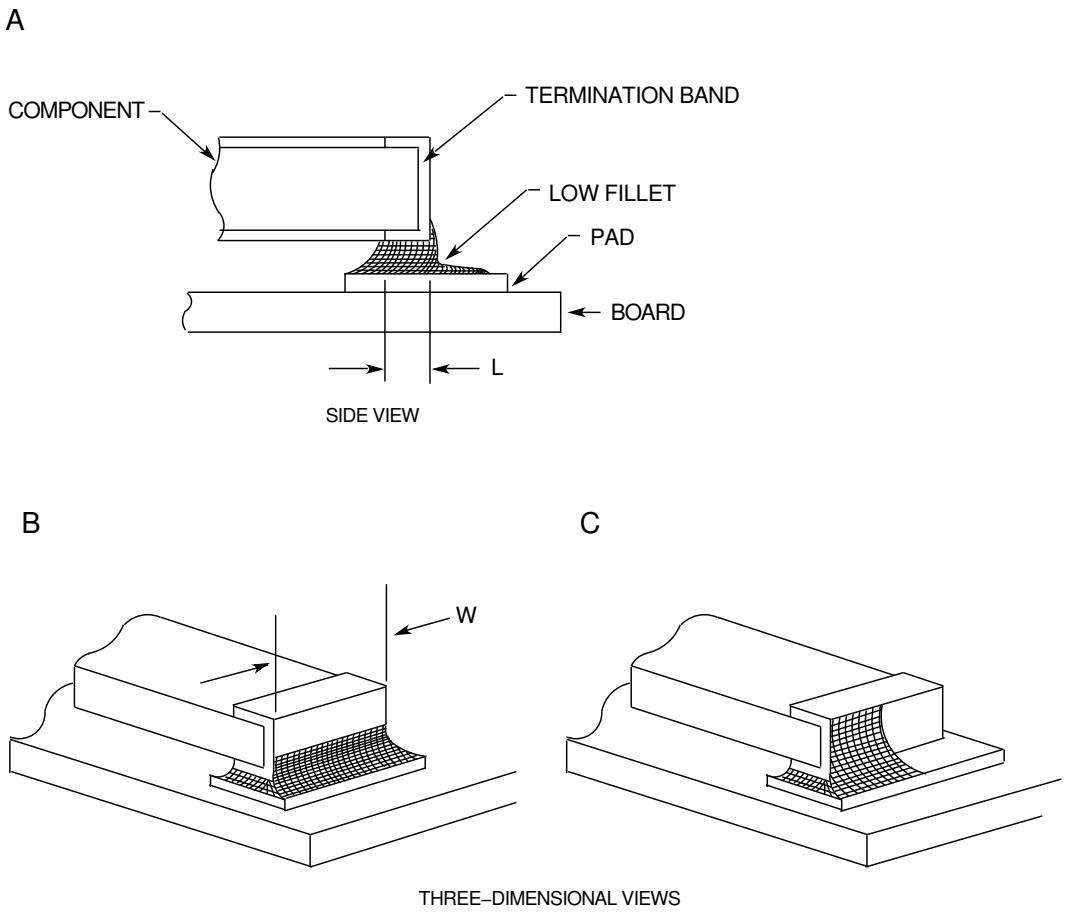
c. Solder does not need to be extended to the edge of the pad, provided there is no evidence of dewetting.

d. Solder fillet has no cracks.

e. The length of the solder fillet must extend the full length of the pad or component termination band (L), whichever is smaller. See Figure 15-A.

f. Solder fillet is at least 50 percent of the termination band width and shows good wetting to the pad. See Figure 15-C.

Figure 15: Minimum Acceptable: Minimal Solder Conditions



7.3 UNACCEPTABLE

The following describes unacceptable solder conditions for chip components and transistors.

7.3.1 Unacceptable: Excessive Solder Conditions

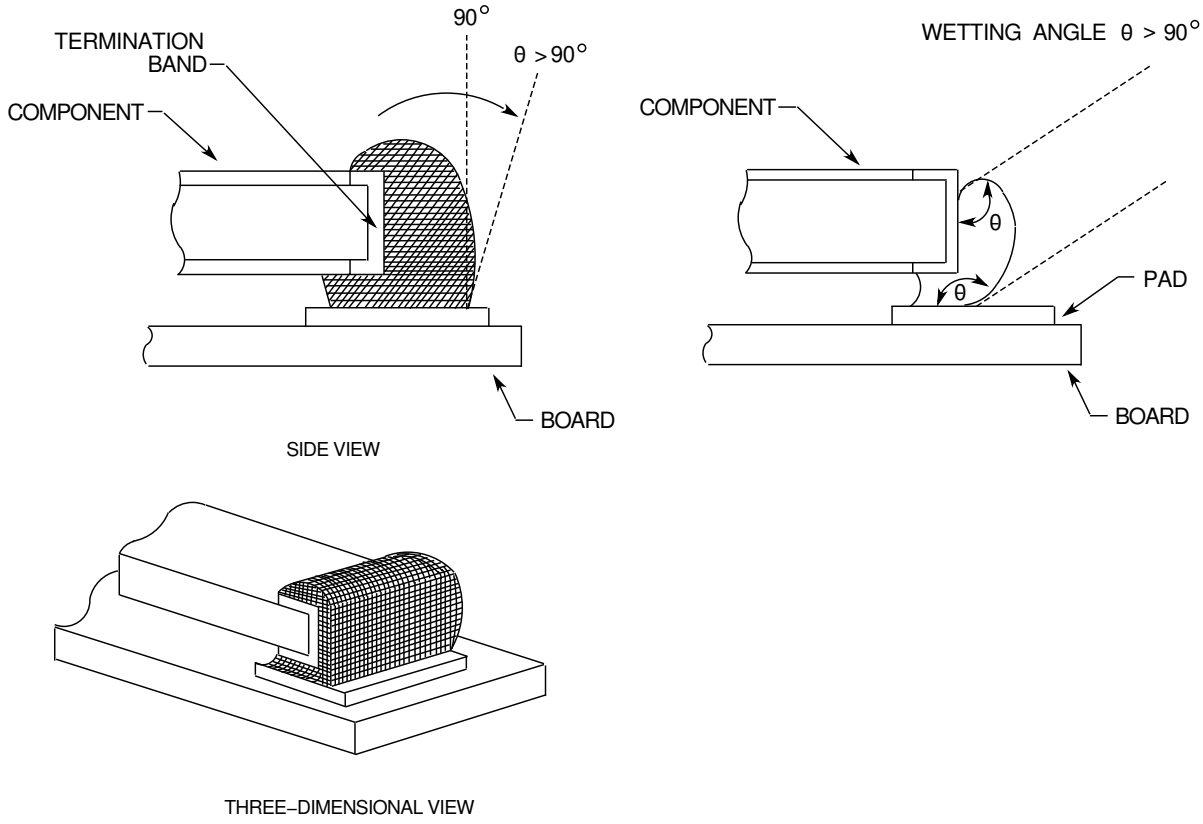
The following describes unacceptable conditions. See Figure 16.

a. Excessive amount of solder is present and bulges out at component pad and body.

b. Cracks in solder fillet are unacceptable.

c. Wetting cannot be verified and wetting exceeds 90 degrees.

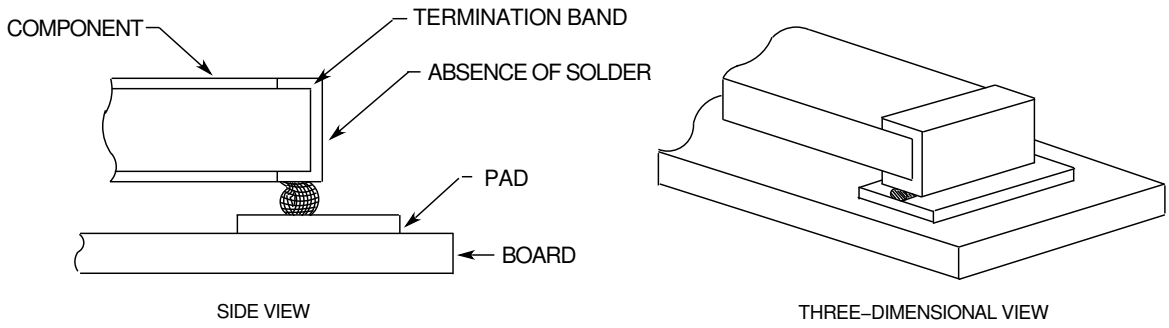
Figure 16: Unacceptable: Excessive Solder Conditions



7.3.2 Unacceptable: Absence of Wetting — Nonwetting Conditions

If solder did not wet to the pad or component, the condition is unacceptable. See Figure 17.

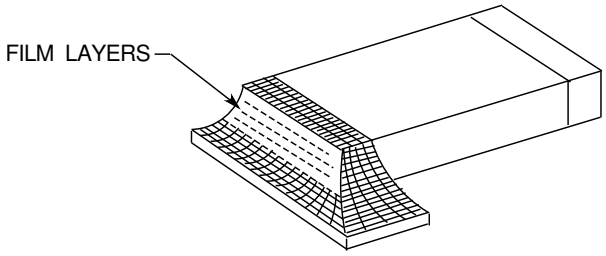
Figure 17: Unacceptable: Absence of Wetting — Nonwetting Conditions



7.3.3 Unacceptable: Leaching

Any exposure of the capacitor film layers in the component due to leaching or dissolving of the end cap termination band is not acceptable and is cause for rejection. See Figure 18.

Figure 18: Unacceptable: Leaching



8 ADHESIVES

The following describes acceptable and unacceptable conditions for adhesives used on surface mount components.

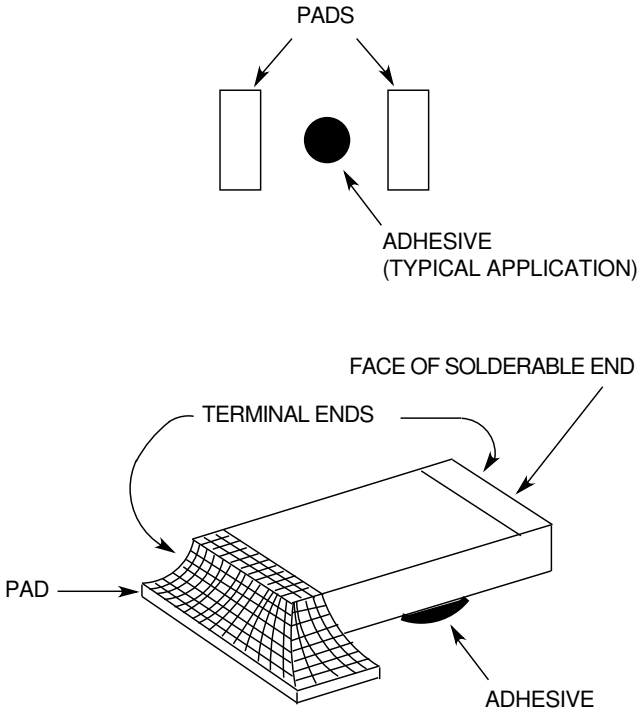
8.1 OPTIMAL (REFERENCE)

The following optimal (reference) conditions apply to wave-soldered surface mount chip components. See Figure 19.

a. There is no visible evidence of adhesive on bands or terminal ends.

b. Adhesive is centered between the pads.

Figure 19: Optimal (Reference): Adhesive Conditions



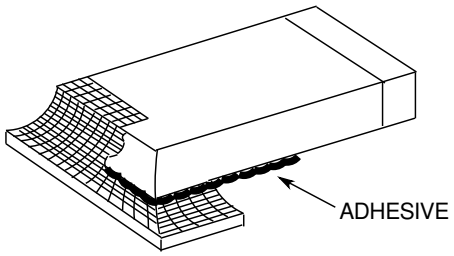
8.2 MINIMUM ACCEPTABLE: ADHESIVE CONDITIONS

Adhesive on the pads or termination bands is acceptable if the following conditions exist. See Figure 20.

a. The adhesive does not cover more than 50 percent of the pad or termination band.

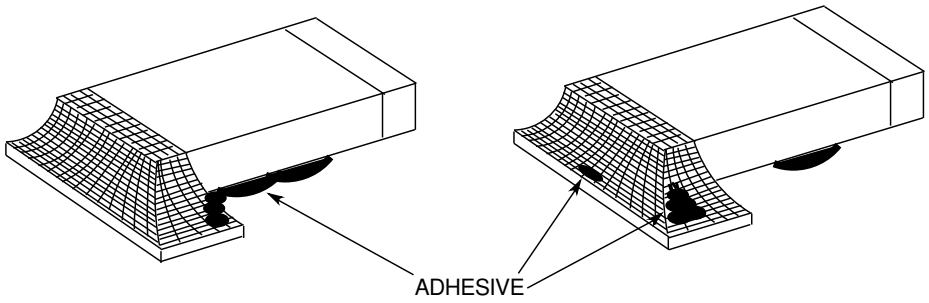
b. The fillet is wetted to the pad and the termination band where there is no adhesive.

Figure 20: Minimum Acceptable: Adhesive Conditions



Adhesive that *sticks to the surface* of the solder fillet is acceptable provided it is not embedded in the solder. See Figure 21.

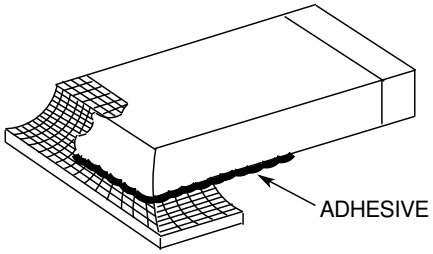
Figure 21: Minimum Acceptable: Adhesive Conditions



8.3 UNACCEPTABLE: ADHESIVE CONDITIONS

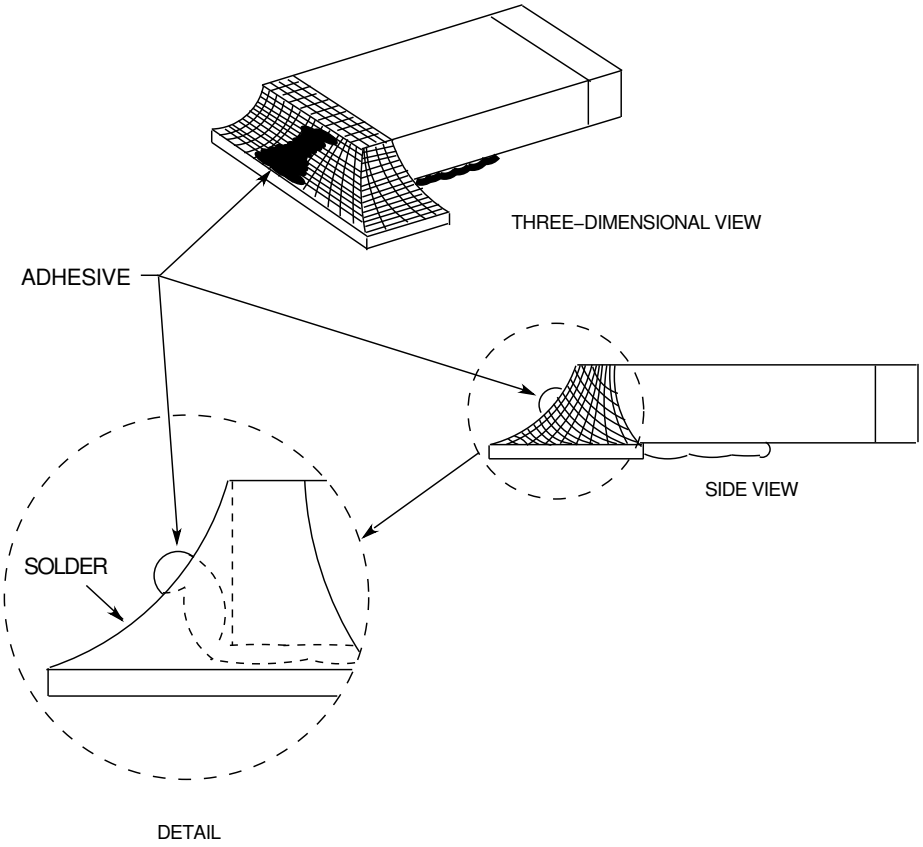
Adhesive may not cover more than 50 percent of the pad or termination band. See Figure 22.

Figure 22: Unacceptable: Adhesive Conditions



Adhesive protruding from the center of any solder fillet is unacceptable and cause for rejection. See Figure 23.

Figure 23: Unacceptable: Adhesive Conditions



9 OPTIMAL (REFERENCE) SOLDERING CONDITIONS — WAVE SOLDER CHIP COMPONENTS (SIDE 2)

The following criteria applies to resistor and capacitor chips that are produced by the wave solder process. See Figure 24.

a. Minimum solder joint is evidence of properly wetted fillet.

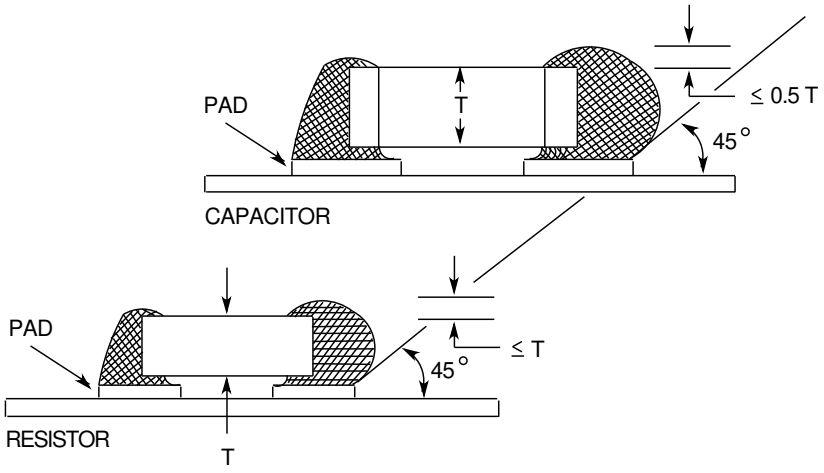
b. Solder fillet, from the top of the component, must not exceed:

0.5 T for capacitors (T = thickness)
T for resistors

c. Solder must be above the 45 degree line from the printed-wiring board surface.

d. The excess solder condition (right side) is only allowed on one end of the component (for stress relief). The other end should not exhibit solder fillet overhang beyond the edge of the pad.

Figure 24: Optimal (Reference) Soldering Conditions — Wave Solder Chip Components (Side 2)



.

10 SOLDERING CONDITIONS — LOW PROFILE SMT DEVICES

The following describes minimum acceptable and unacceptable soldering conditions that may exist after reflow or wave soldering with low profile devices such as SOICs, SOTs, TSOPs, SSOPs, or LEDs. See Figure 25.

10.1 MINIMUM ACCEPTABLE

a. Solder overhangs the pad areas. (Refer to heading 5.)

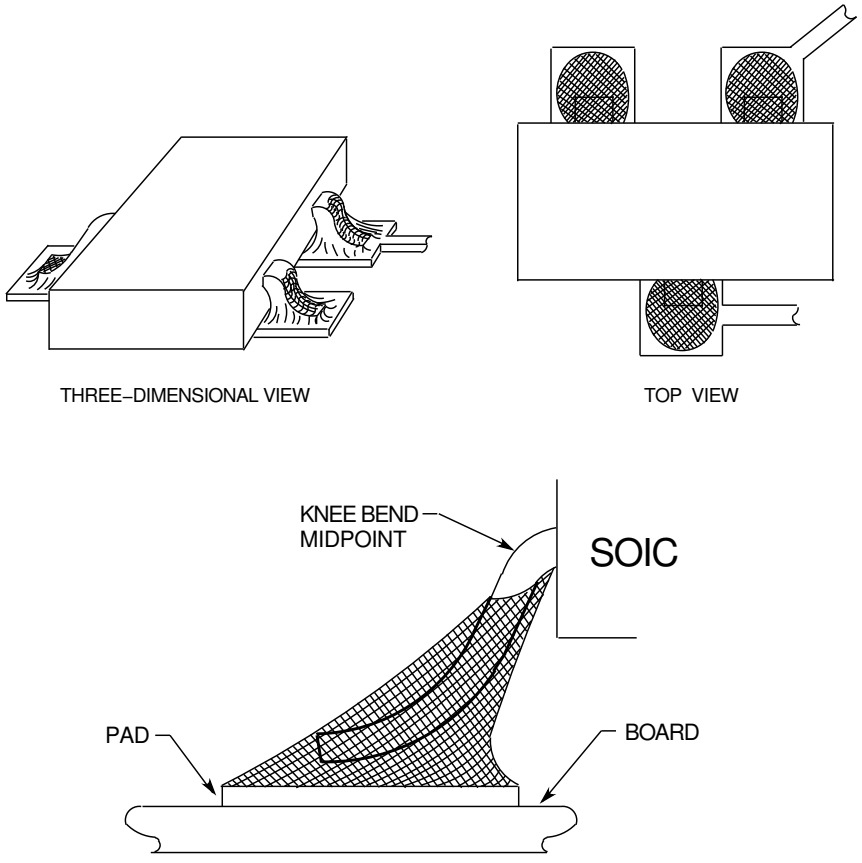
b. Lead outline is not visible.

c. Solder touches component body but does not extend underneath.

d. Solder on SOIC devices may touch the body or extend above the knee bend.

e. SOIC lead outline is not visible and solder may overhang the pad.

Figure 25: Soldering Conditions — Low Profile SMT Devices



10.2 UNACCEPTABLE

The following describes unacceptable solder conditions for low profile SMT devices.

a. Solder fillet has cracks.

b. Solder flows under the component body.

11 SOLDERING CONDITIONS — J-BEND LEADED COMPONENTS

The following criteria applies to 50-mil pitch J-bend leaded components.

11.1 OPTIMAL (REFERENCE)

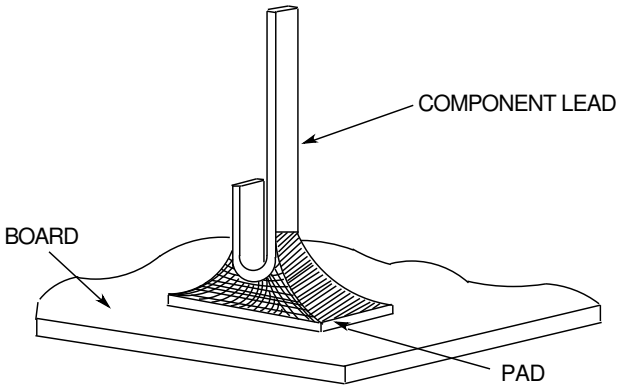
The following describes optimal (reference) conditions. See Figure 26.

a. Good solder fillet has a concave appearance, is smooth, no grainy appearance, and has a smooth transition from both component lead and pad terminations.

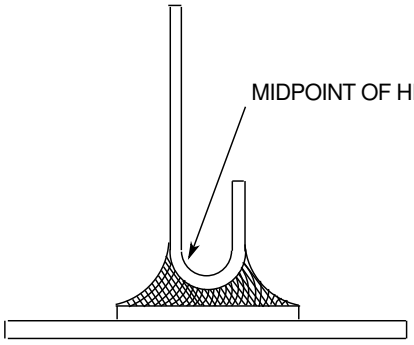
b. There is full solder coverage on pad and above midpoint of heel.

c. Solder fillet has no cracks.

Figure 26: Optimal (Reference): Soldering Conditions — J-Bend Leaded Components



THREE–DIMENSIONAL VIEW



SIDE VIEW

11.2 MINIMUM ACCEPTABLE

The following describes acceptable and unacceptable solder conditions for j-bend leaded components.

11.2.1 Minimum Acceptable: Maximum Solder Conditions

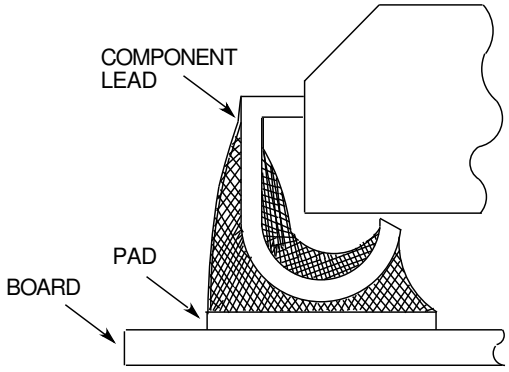
The following describes minimum acceptable conditions. See Figure 27.

a. Solder fillet has a convex appearance and may overhang the pad. (Refer to heading 5)

b. Good wetting is visible at the edges of pad and component.

c. Solder fillet has no cracks.

Figure 27: Minimum Acceptable: Maximum Solder Conditions



11.2.2 Minimum Acceptable: Minimal Solder Conditions

The following describes minimum acceptable conditions.

a. There is a low solder fillet and solder flows to one-half (H) the lead thickness (T) measured at the lowest point of the inside bend radius of the lead (A). See Figure 28-A.

b. Solder wetting is visible at component lead and on pad.

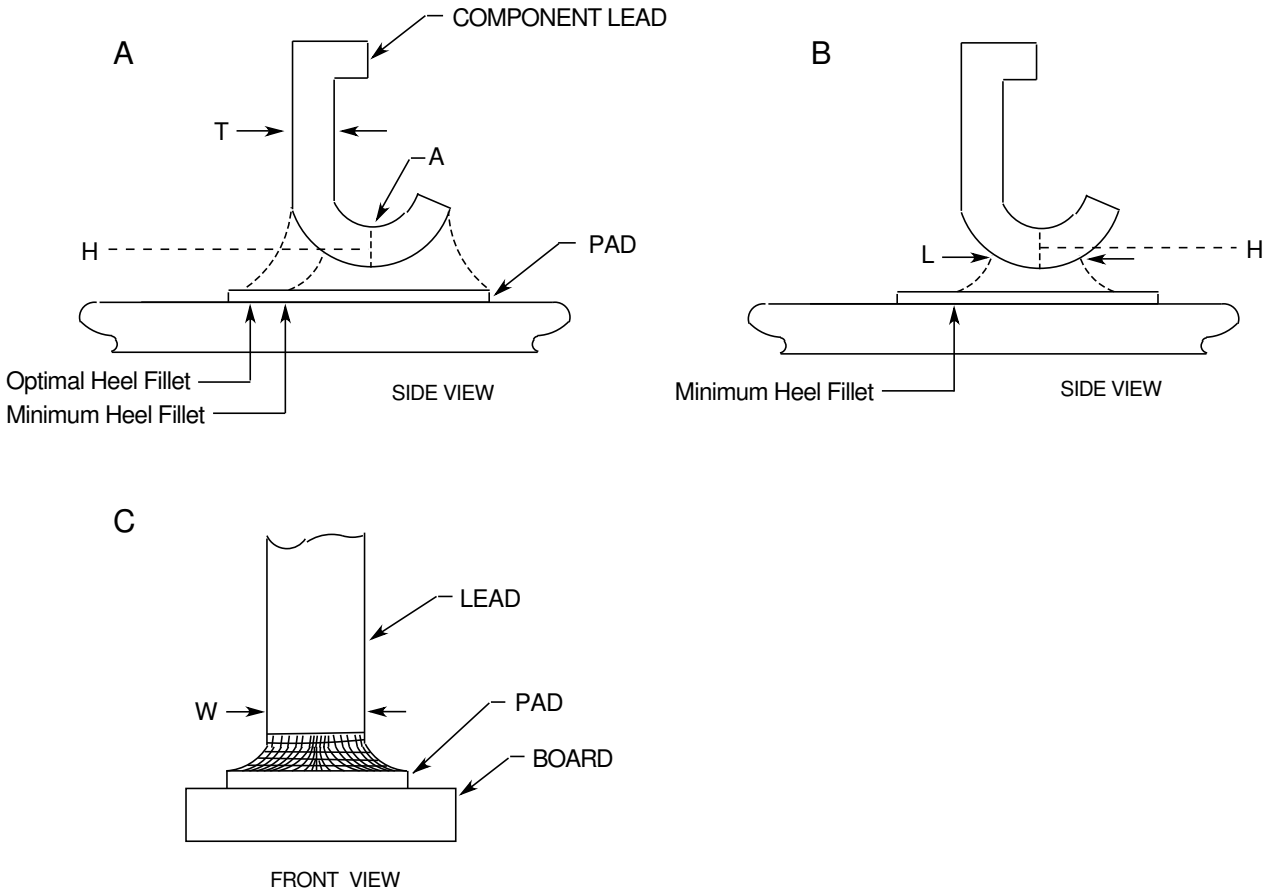
c. The length (L) of the solder fillet is at least equal to one and one-half times the width (W) of the lead. See Figure 28-B and 28-C.

d. Solder does not need to extend to the edge of the pad.

e. Dewetting at the edge of the pad is acceptable.

f. Solder fillet has no cracks.

Figure 28: Minimum Acceptable: Minimal Solder Conditions



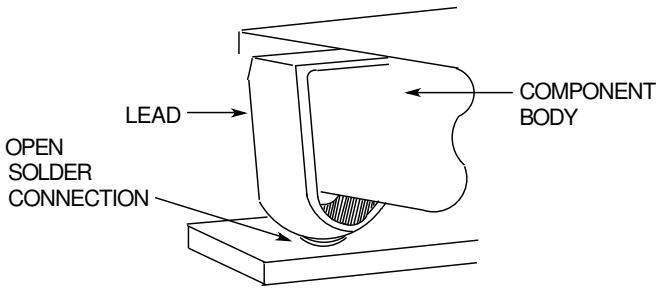
11.3 UNACCEPTABLE

The following describes unacceptable solder conditions for j-bend leaded components.

11.3.1 Unacceptable: Insufficient Solder Conditions

Solder does not flow to the midpoint of the heel on the component lead. See Figure 29.

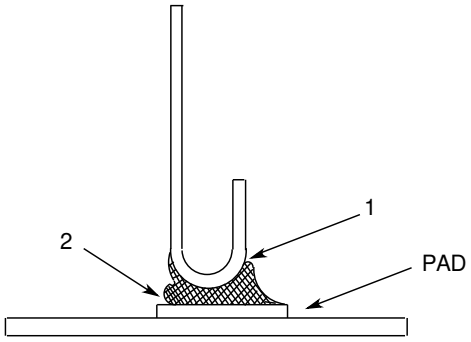
Figure 29: Unacceptable: Insufficient Solder Conditions



11.3.2 Unacceptable: Absence of Wetting (Nonwetting)

Absence of wetting at component lead (1) or pad (2). See Figure 30.

Figure 30: Unacceptable: Absence of Wetting (Nonwetting)



12 SOLDERING CONDITIONS — GULL-WING LEAD COMPONENTS (50-MIL AND 25-MIL PITCH)

The following soldering criteria apply to components with gull-wing leads.

12.1 OPTIMAL (REFERENCE)

The following describes optimal (reference) conditions. See Figure 31.

a. Good solder fillet has concave appearance on both sides and heel.

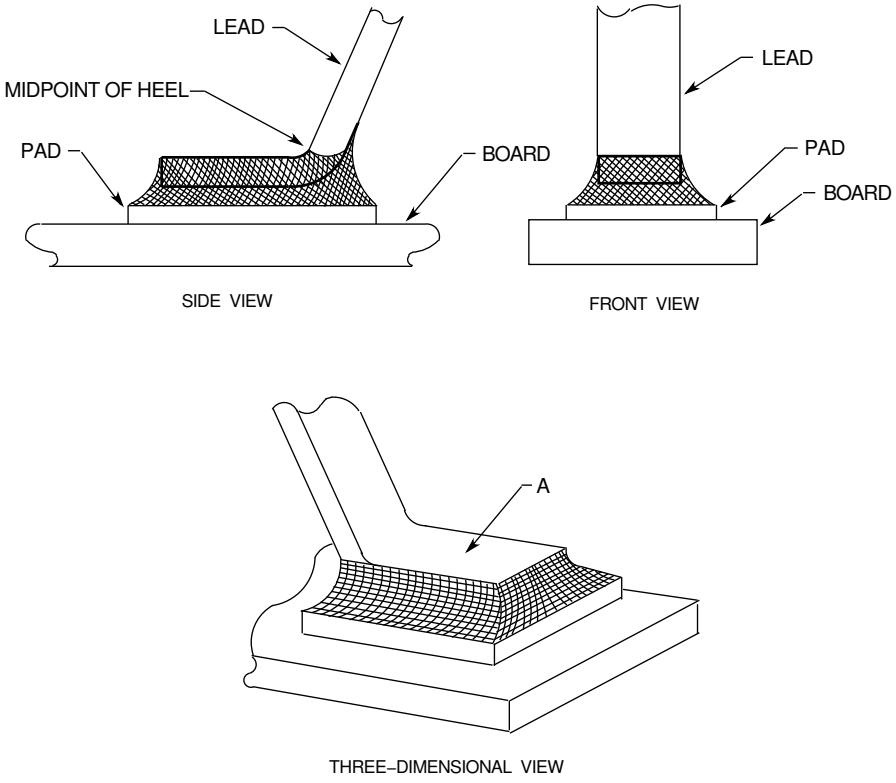
b. There is full coverage of solder on pad and lead above midpoint of heel.

c. Solder fillet has no cracks.

d. There is good lead-to-pad alignment (See heading 17).

e. Lead outline is visible in the solder fillet.

Figure 31: Optimal (Reference): Soldering Conditions — Gull-Wing Lead Components



12.2 MINIMUM ACCEPTABLE

The following describes minimum acceptable solder conditions for gull-wing leaded components (50-mil and 25-mil pitch).

12.2.1 Minimum Acceptable: Maximum Solder Conditions

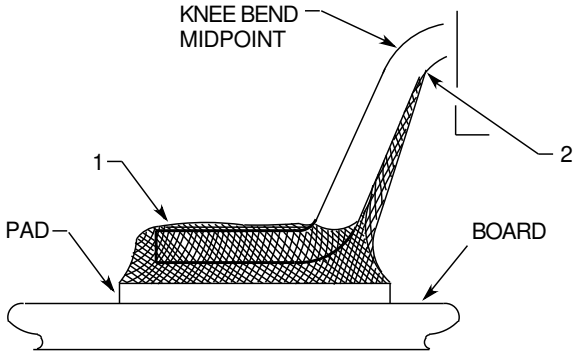
The following describes minimum acceptable conditions. See Figure 32.

a. Solder on top of the lead is acceptable (1).

b. Heel fillet must not extend above the midpoint of the knee bend (2).

c. There is good wetting visible at the edges of pad and component lead.

Figure 32: Minimum Acceptable: Maximum Solder Conditions



12.2.2 Minimum Acceptable: Minimal Solder Conditions

The following describes minimum acceptable conditions. See Figure 33.

a. Solder fillet present on both sides of component lead and up the heel.

b. Solder fillet has no cracks.

c. The length of the solder fillet must be equal to the width (W) of the lead.

d. Heel fillet must extend to a minimum of one-half (H) the thickness of the lead (T). See note.

e. Solder does not need to extend to the edge of the pad.

f. Dewetting at the end of the pad is acceptable.

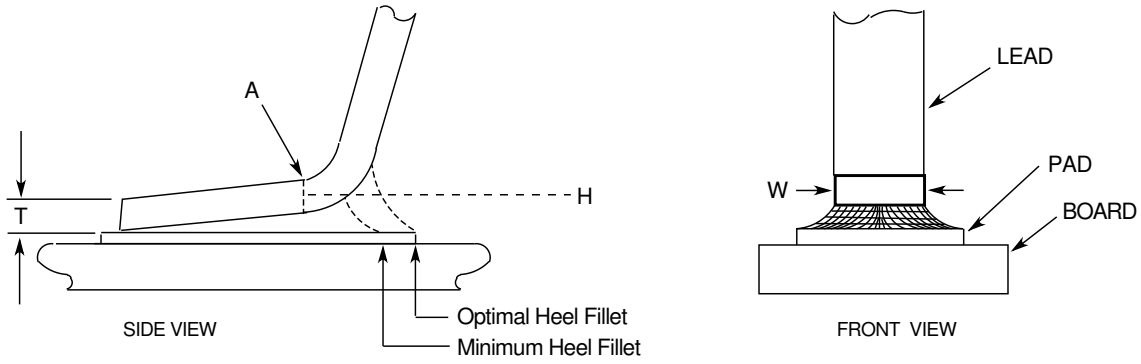
g. Allowable pad-to-lead solderable surfaces are properly wetted.

h. Exposed lead base material on lead tip is acceptable.

NOTE

The minimum acceptable fillet height criteria is referenced to one half the thickness (0.5 T) of the lead. The height of the heel fillet, to a formed lead, must be measured at the lowest point of the inside bend radius of the lead as indicated by "A". See Figure 33.

Figure 33: Minimum Acceptable — Minimal Solder Conditions



12.3 UNACCEPTABLE

The following describes unacceptable solder conditions for gull-wing leaded components (25-mil and 50-mil pitch).

12.3.1 Unacceptable: Excessive Solder Conditions

The following describes unacceptable conditions. See Figure 34.

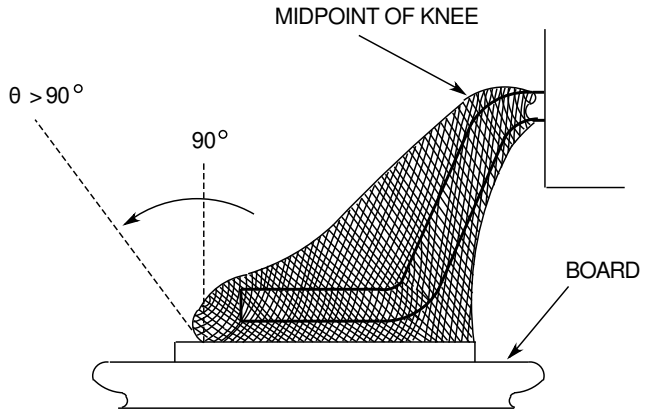
a. Excessive amounts of solder at the fillet and wetting angle exceeding 90 degrees is unacceptable.

b. Cracks are in the solder fillet.

The following unacceptable condition apply to gull-wing leads.

c. Fillet is above midpoint of knee on the outside of the lead.

Figure 34: Unacceptable: Excessive Solder Condition



12.3.2 Unacceptable: Insufficient Solder Conditions

The following describes unacceptable conditions. See Figure 35.

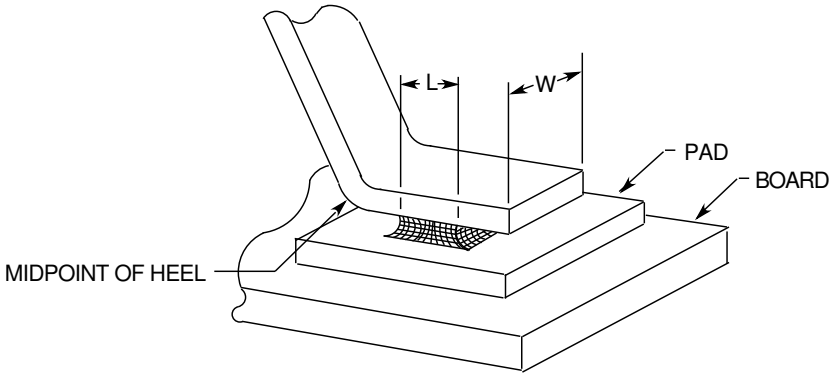
a. Solder fillet length (L) is less than the width (W) of the lead.

b. Solder fillet is not at least up to midpoint of heel bend.

c. Condition does not meet the minimum acceptance criteria described in subhead 12.2.2.

d. Cracks are in the solder fillet.

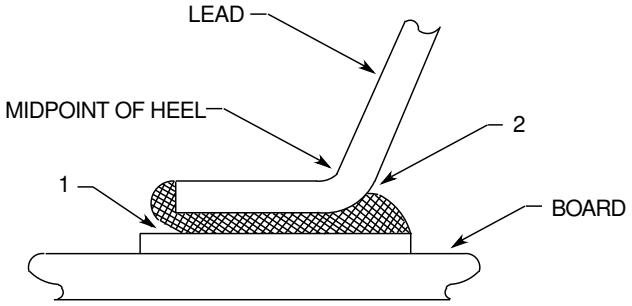
Figure 35: Unacceptable: Insufficient Solder Conditions



12.3.3 Unacceptable: Absence of Wetting (Nonwetting)

Absence of wetting at component pad (1) or lead (2). See Figure 36.

Figure 36: Unacceptable: Absence of Wetting (Nonwetting)



13 SOLDERING CONDITIONS — BUTT JOINTS

The following describes soldering conditions for butt joints.

13.1 GENERAL

Leads designed without wettable sides (such as leads stamped or sheared from preplated stock) are not required to have side fillets.

13.2 OPTIMAL (REFERENCE) AND MINIMUM ACCEPTABLE

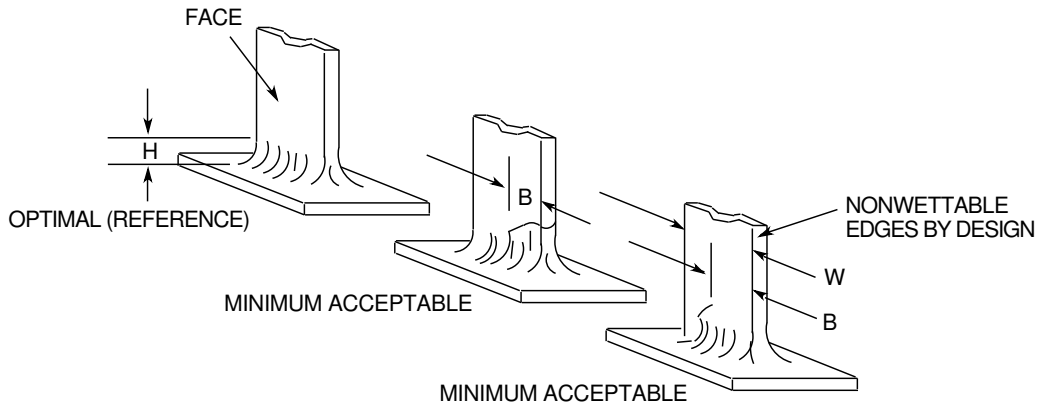
The following describes optimal (reference) and minimum acceptable conditions. See Figure 37.

a. Fillet height (H) must be at least equal to one-half of the lead width (W).

b. Fillet length (B) must be at least equal to three-quarters of the lead width (W) and exhibit good wetting characteristics.

c. Good wetting visible at the edges of pad and component.

Figure 37: Optimal (Reference) and Minimum Acceptable: Butt Joint Soldering Conditions



14 PAD ALIGNMENT — J-BEND LEADED COMPONENTS

The following describes pad alignment workmanship conditions for J-bend leaded components.

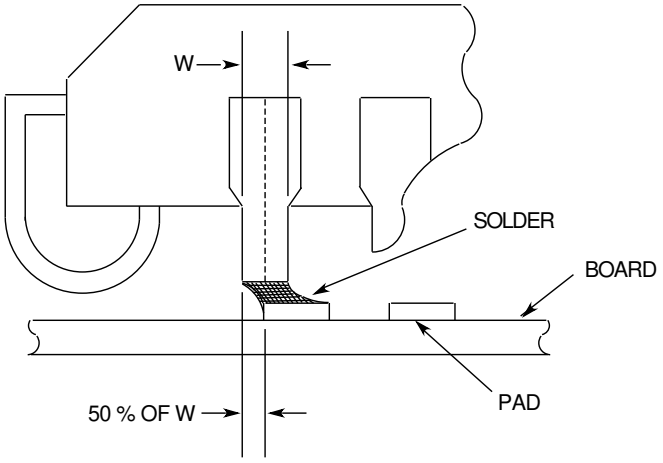
14.1 OPTIMAL (REFERENCE)

Component leads are accurately aligned with printed-wiring board pads.

14.2 MINIMUM ACCEPTABLE

Misalignment does not exceed 50 percent of lead width (W). See Figure 38

Figure 38: Minimum Acceptable: Pad Alignment — J-Bend Leaded Components



14.3 UNACCEPTABLE

The condition is unacceptable if the component lead is off the pad more than 50 percent of the lead width.

15 PAD ALIGNMENT — LEADLESS CHIP CARRIERS

Component contact areas should be properly aligned with the printed-wiring board pads to ensure good electrical contact. The following describes pad alignment workmanship conditions for leadless chip carriers.

15.1 OPTIMAL (REFERENCE)

Component castellations are 100 percent aligned with printed-wiring board pads.

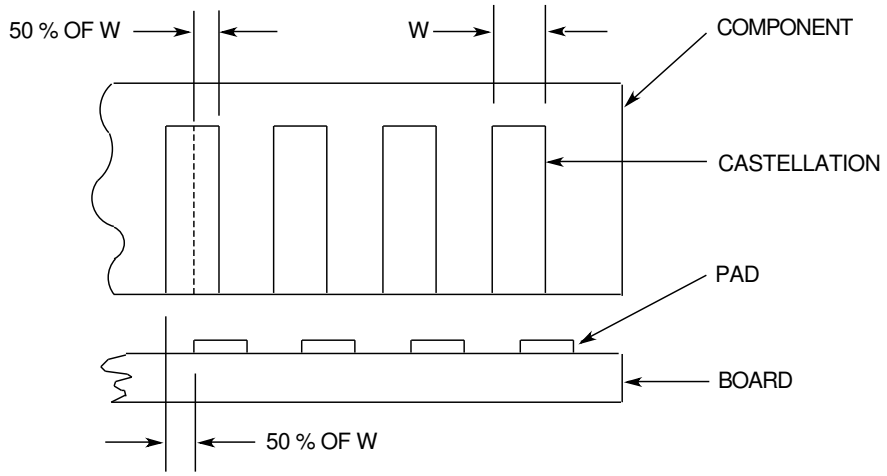
15.2 MINIMUM ACCEPTABLE: PAD ALIGNMENT — LEADLESS CHIP CARRIERS

Misalignment is less or equal to 50 percent of component castellation width (W). See Figure 39.

15.3 UNACCEPTABLE: PAD ALIGNMENT — LEADLESS CHIP CARRIERS

Misalignment exceeds 50 percent of component lead castellation width.

Figure 39: Minimum Acceptable: Pad Alignment — Leadless Chip Carriers



.

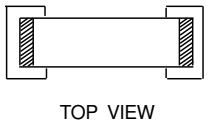
16 CHIP COMPONENT ALIGNMENT

The following describes alignment conditions for chip components.

16.1 OPTIMAL (REFERENCE)

Component is centered on both sides of the pads. See Figure 40.

Figure 40: Optimal (Reference): Chip Component Alignment



16.2 ACCEPTABLE MINIMUM: CHIP COMPONENT ALIGNMENT

The following describes acceptable minimum alignment conditions for chip components.

a. Component is shifted towards longest part of the chip, but the terminal end of the chip is flush with the pad. One terminal end must maintain .25 W of the pad for the solder fillet to form. See Figure 41-A.

b. Both sides shifted in the same direction. No more than one-half of the chip's width (W) is shifted off the pad. See Figure 41-B.

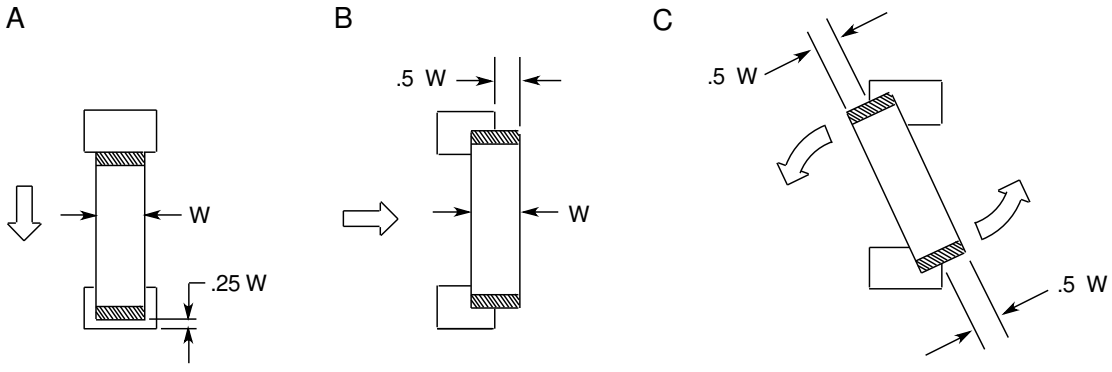
c. Chip's sides are shifted in opposite direction, but not more than one-half of the width on one or both ends of component (see arrows). See Figure 41-C.

d. Shifted component must not violate minimum spacing requirements of product technology.

e. End-to-end shifted components must have end termination touching pad.

f. Three- and five-sided terminated chip components mounted upside down are acceptable.

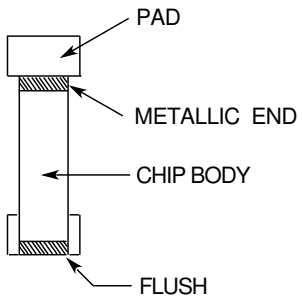
Figure 41: Acceptable Minimum: Chip Component Alignment



16.3 UNACCEPTABLE

If the component terminal end is "flush" or overhangs the edge of the outer pad, the condition is unacceptable. See Figure 42.

Figure 42: Unacceptable: Component Alignment



17 PAD ALIGNMENT — GULL-WING COMPONENTS (25 AND 50 MIL-RIGID, FLEX-LEAD TAPE-BONDED COMPONENTS)

The following conditions apply to component alignment.

17.1 Optimal (Reference)

Gull-wing leads are accurately aligned with footprint pads.

17.2 Minimum Acceptable: Pad Alignment — Gull-Wing Components

The following describes minimum acceptable alignment conditions for gull-wing components. See Figure 43.

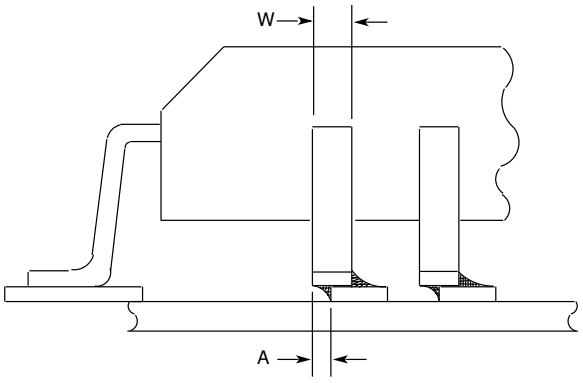
a. Misalignment does not exceed maximum percentage described in Table 1.
b. Fillet must be present at heel and side of the lead that is on the pad.

17.3 Unacceptable: Pad Alignment — Gull-Wing Components

The following describes unacceptable alignment conditions for gull-wing components.

a. Misalignment exceeds dimension described in Table 1.
b. Fillet is not present at heel and side of the lead that is on the pad.

Figure 43: Pad Alignment — Gull-Wing Components



17.4 Rotational Misalignment of Lead-On-Pad

Solder conditions must meet minimum requirements as described in subhead 12.2.2.

The lead may overhang its pad but not violate "minimum acceptable clearance", which is half the minimum designed spacing used in the subject printed-wiring board technology. Refer to Figure 44.

For example, for 5/5 technology, typical space equals 0.13 mm (.005 inch), so minimum acceptable clearance equals 0.06 mm (.0025 inch).

Figure 44: Pad Alignment — Lead-to-Pad Clearance

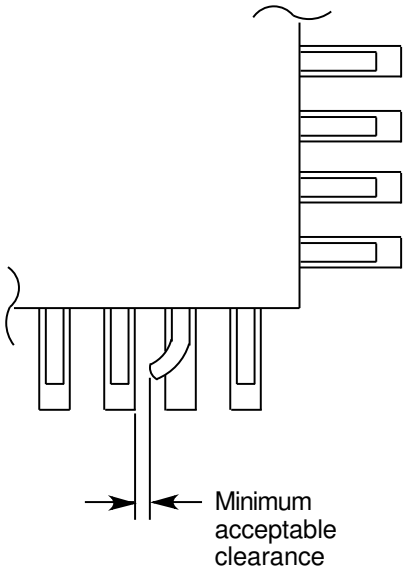


Table 1: Maximum Allowable Lead-to-Pad Misalignment

Dimension	12 ½-mil pitch	0.5 mm pitch	25-mil pitch	50-mil pitch
A	50% of W	50% of W	50% of W	50% of W

17.5 FLEX-LEAD (12 ½-MIL PITCH) TECHNOLOGY NOTES

The following information are technology notes related to flex-lead (12½-mil pitch) conditions.

17.5.1 Technology Qualifier

All references to 12½-mil Pitch Flex-Lead Technology are the result of development and low volume manufacturing with a 332 I/O, single metal layer, selectively solder plated, tape device which is attached to a CSP (controlled solder plate) or solder deposited substrate footprint. The process developed has not been tested for high volume application.

No inferences to applicability or suitability of this module assembly process to other flexible leaded package types can be made without sufficient additional engineering investigation.

18 DAMAGED COMPONENTS - SURFACE MOUNT ASSEMBLIES

Refer to the *surface mount component damage* section of *ANSI/IPC-A-610A, Acceptability of Electronic Assemblies* for information on this subject.

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00030-03	*DEC STD 030-3 Module Manufacturing Standard - Component Selection Rules*
EL-00067-00	*DEC STD 067-0 Electrostatic Discharge - Sensitive Devices*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

A.2 Other Documents

Document Number	Document Title
ANSI/IPC-A-610A	*Acceptability of Electronic Assemblies*

For a copy of the above document:

In the USA:
American National Standards Institute (ANSI)
11 West 42nd Street, 13th Floor
New York, NY 10036
Telephone (212-642-4934)

In other countries:

The National Standards Organization

APPENDIX B RELATED DOCUMENTS

B.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-EN705-00	*Footprint Patterns for Surface Mount Technology*
EL-MF417-01	*Surface Mount Technology Reference Manual - 2 Volume Set*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

```
+-------------------------------------------------------------------+
|                        READER COMMENTS                            |
|                                                                   |
| Your  comments  and suggestions  will help  Standards and Methods |
| Control improve their services and documents.                     |
+-------------------------------------------------------------------+
```

Did you request this document? _____ If so, did it arrive within a satisfactory period of time? _____ Please comment.

What are your impressions of this document? Consider format, organization, completeness, readability, and illustrations.

————————————**FOLD ON THIS LINE**———————————————————————— -

Did you find technical or clerical errors in this document? If so, please specify the page number(s) and the error(s).

Are the instructions for the update package clear? _____
Was an index available? _____ If not, is one needed? _____
Do you have other suggestions for improving this document?

The following information is optional:

Name _____ Mailstop _____

Department _____ Node _____

Send your comments to JOKUR::PROJECTS, or fold, staple, and send this page through interoffice mail to:

```
+------------------------------+
|       READERS' COMMENTS      |
| STANDARDS AND METHODS CONTROL |
|           NRO5/I2            |
+------------------------------+
```